



National Renewable Energy Laboratory
Innovation for Our Energy Future

SAM Geothermal Analysis



Webinar

Tom Ferguson

June 2011



- Introduction to SAM
- Modeling a geothermal facility
- Running SAM, Viewing Results
- Advanced Topics
- Demonstration



SAM Geothermal Analysis

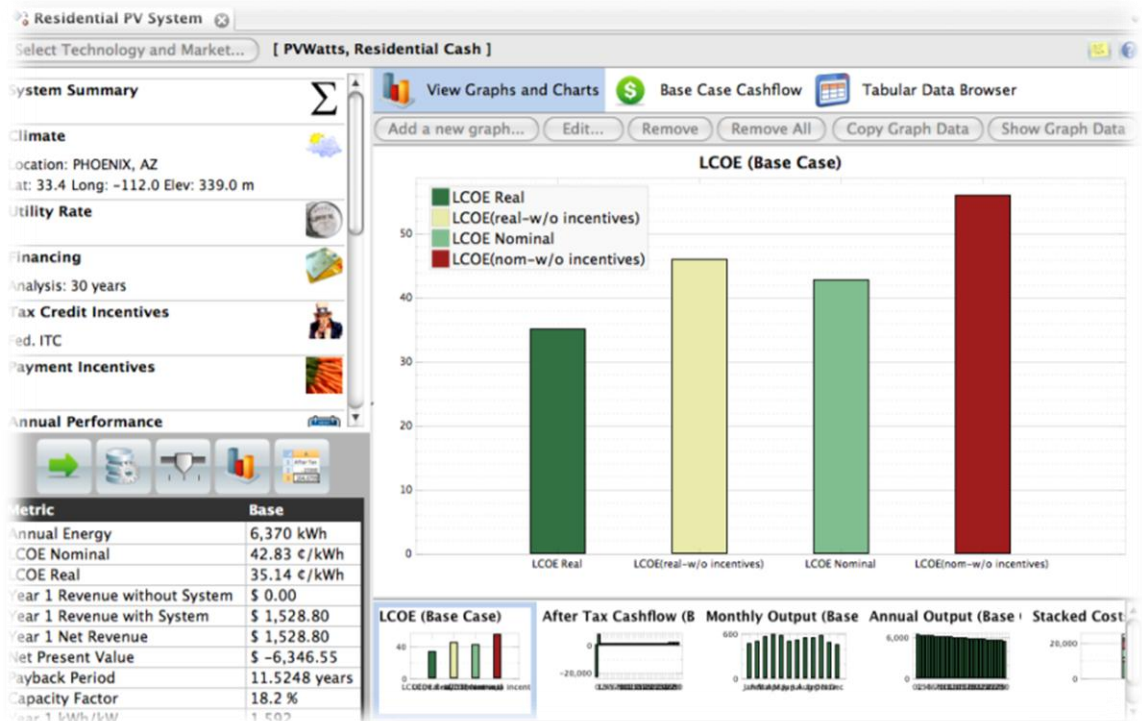
INTRODUCTION TO SAM

What is SAM?



The System Advisor Model (SAM) is a free computer program that **calculates a renewable energy system's energy output**, and **calculates the cost of energy** for a renewable energy project over the life of the project.

These calculations are done using detailed performance models, a detailed cash flow finance model, and a library of reasonable default values for each technology and target market.



What can you do with SAM?



- Model solar, wind, and geothermal power systems in a single application
- Access high-quality performance and economic models developed by NREL, Sandia, and other partners
- Evaluate and compare options using consistent models across technologies
- Calculate economic metrics such as LCOE, NPV, payback for projects in different markets
- Perform parametric and uncertainty analyses
- Present modeling results in graphs and tables



- Photovoltaics
- Concentrating Solar Power
 - Parabolic Troughs
 - Power Towers
 - Dish-Stirling
- Solar Water Heating
- Wind turbines and farms
- Geothermal power plants

Key outputs

- Hourly energy production (kWh)
- Capacity factor

- Residential, commercial, and utility-scale projects
- Installation and operating costs
- Tax credit and payment incentives
- Complex electric utility rates

Key outputs

- Levelized Cost of Electricity (LCOE)
- Payback
- Net present value
- Multi-year cash flow

Background



Developed by the Department of Energy, National Renewable Energy Laboratory, and Sandia National Laboratories

Vision

- Model different renewable energy projects in a single platform
- Facilitate technology comparison by handling performance, costs and financing consistently across technologies
- Make high-quality performance models developed by NREL, Sandia, and other partners available to the public

Users and Applications



Feasibility studies

- Project developers, Federal Energy Management Program

Use as benchmark for other models

- System integrators and utilities

Research projects

- Universities and engineering firms

Plant acceptance testing for parabolic trough systems

Evaluate technology research opportunities and grant proposals

- Department of Energy

35,000+ Downloads

Manufacturers
Engineering Firms
Consultants
Developers
Venture Capitalists
Policy Analysts

Current Development Team



Management

- Nate Blair, NREL

Programming

- Aron Dobos, NREL
- Steven Janzou, NREL*
- Tom Ferguson, NREL*

PV Model Validation

- Chris Cameron, Sandia

Photovoltaics

- Bolko von Roedern, NREL

Concentrating Solar Power

- Mark Mehos, NREL
- Craig Turchi, NREL

Water Heating

- Jay Burch, NREL
- Craig Christensen, NREL

Geothermal

- Chad Augustine, NREL

Documentation and User Support

- Paul Gilman, NREL*

* Contractors



SAM has two models related to geothermal electricity production: Geothermal Power, and Geothermal Co-Production

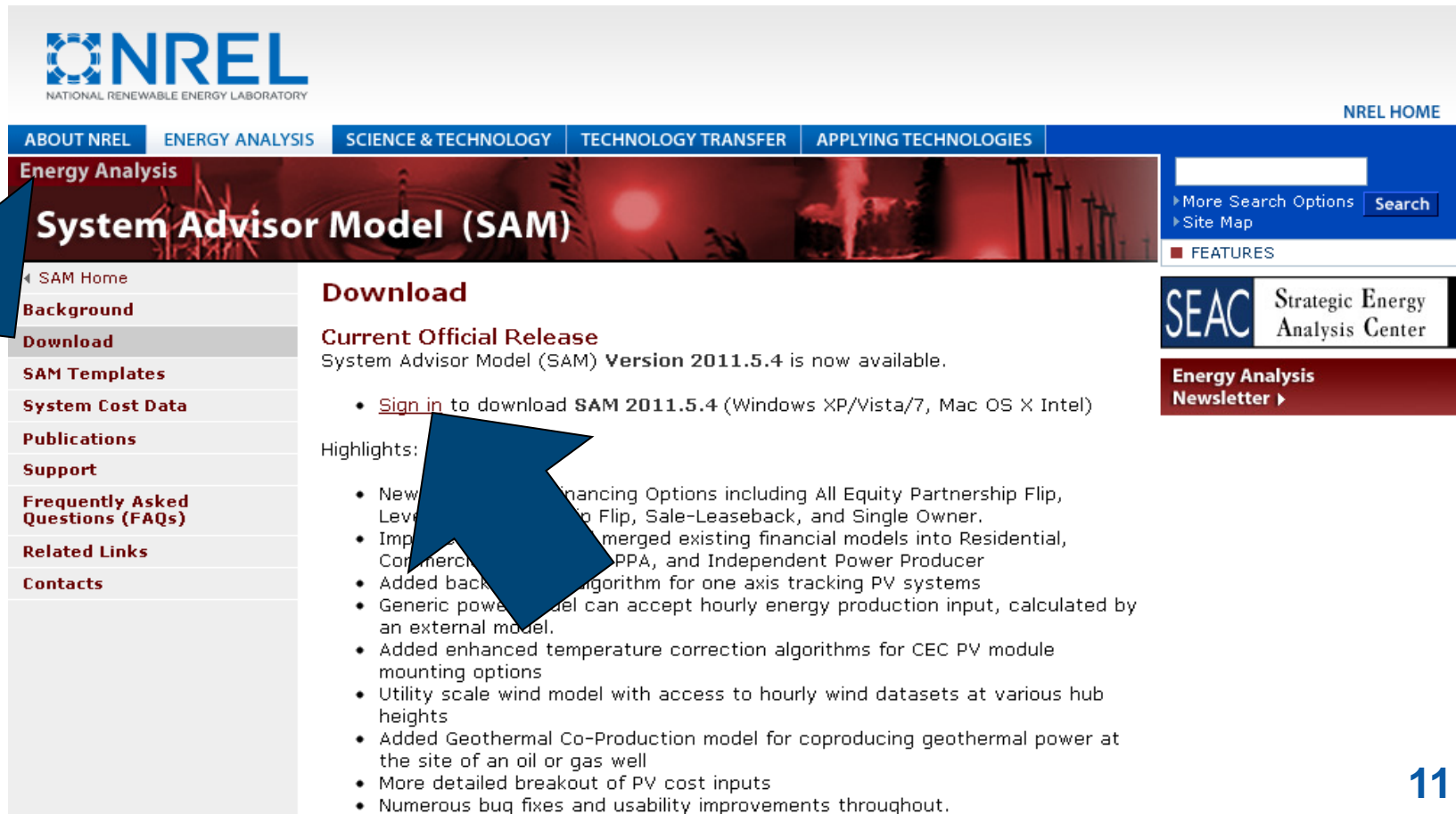
- Geothermal power model
 - Based on the “Geothermal Electricity Technology Evaluation Model” (GETEM)
 - Performance model is run monthly over lifetime of project
 - Lookup resource information for locations in continental US
 - Predicts resource degradation over years
 - Accounts for parasitic losses from pumps
- Geothermal co-production model
 - Simple calculation of thermal or utilization efficiency to determine electrical output from thermal energy available, no simulation
 - Choose between theoretical models, or model output based on a PureCycle unit

Downloading SAM



<http://www.nrel.gov/analysis/sam>

1) Sign in 2) Complete registration form 3) Download



The screenshot shows the NREL SAM website. A large blue arrow on the left points to the 'Download' link in the left-hand navigation menu. Another large blue arrow on the right points to the 'Sign in' link in the 'Current Official Release' section. The website header includes the NREL logo and navigation tabs for 'ABOUT NREL', 'ENERGY ANALYSIS', 'SCIENCE & TECHNOLOGY', 'TECHNOLOGY TRANSFER', and 'APPLYING TECHNOLOGIES'. The main content area is titled 'System Advisor Model (SAM)' and features a 'Download' section with the 'Current Official Release' of SAM 2011.5.4. A search bar and 'More Search Options' link are visible in the top right corner.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

ENERGY ANALYSIS

System Advisor Model (SAM)

Download

Current Official Release
System Advisor Model (SAM) **Version 2011.5.4** is now available.

- [Sign in](#) to download **SAM 2011.5.4** (Windows XP/Vista/7, Mac OS X Intel)

Highlights:

- New financing Options including All Equity Partnership Flip, Lease-to-Own Flip, Sale-Leaseback, and Single Owner.
- Improved financial models merged existing financial models into Residential, Commercial, PPA, and Independent Power Producer
- Added backtracking algorithm for one axis tracking PV systems
- Generic power model can accept hourly energy production input, calculated by an external model.
- Added enhanced temperature correction algorithms for CEC PV module mounting options
- Utility scale wind model with access to hourly wind datasets at various hub heights
- Added Geothermal Co-Production model for coproducing geothermal power at the site of an oil or gas well
- More detailed breakout of PV cost inputs
- Numerous bug fixes and usability improvements throughout.

SEAC Strategic Energy Analysis Center

Energy Analysis Newsletter

Getting Help



Online Help and User Guide

- Help menu and buttons



SAM Website

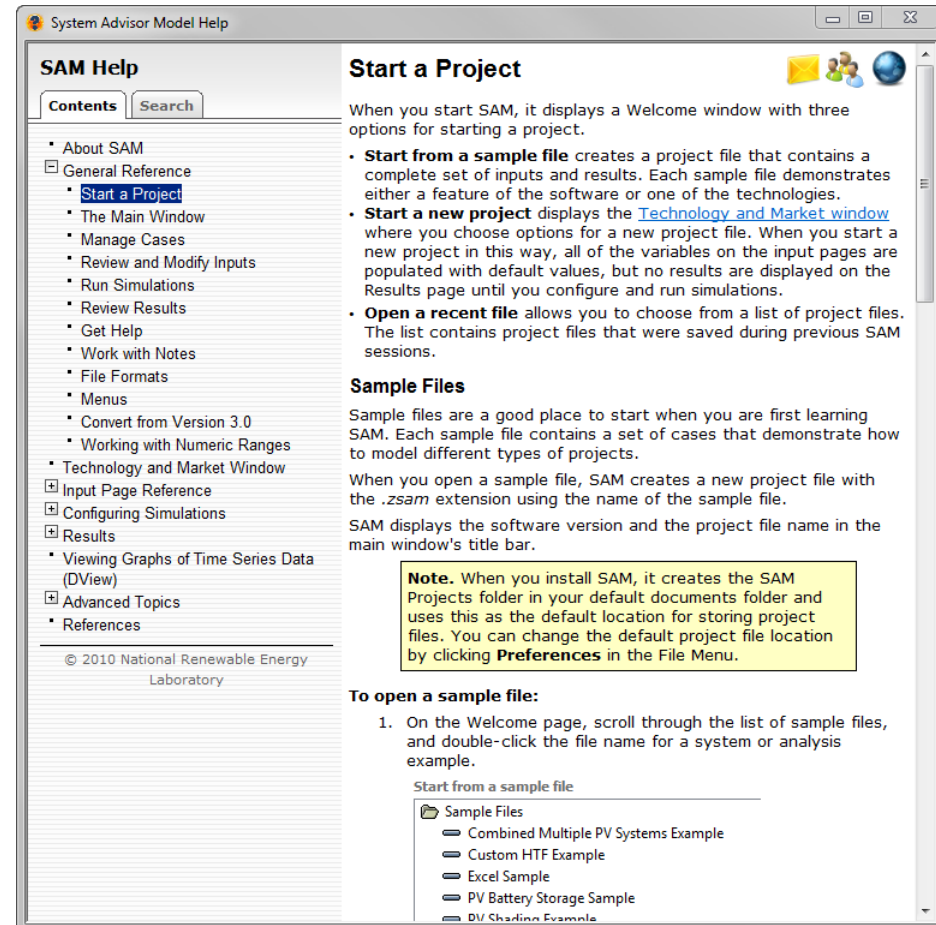
- <http://www.nrel.gov/analysis/sam>

Google Groups

- <http://groups.google.com/group/sam-user-group>

Email User Support

- solar.advisor.support@nrel.gov





SAM Geothermal Analysis

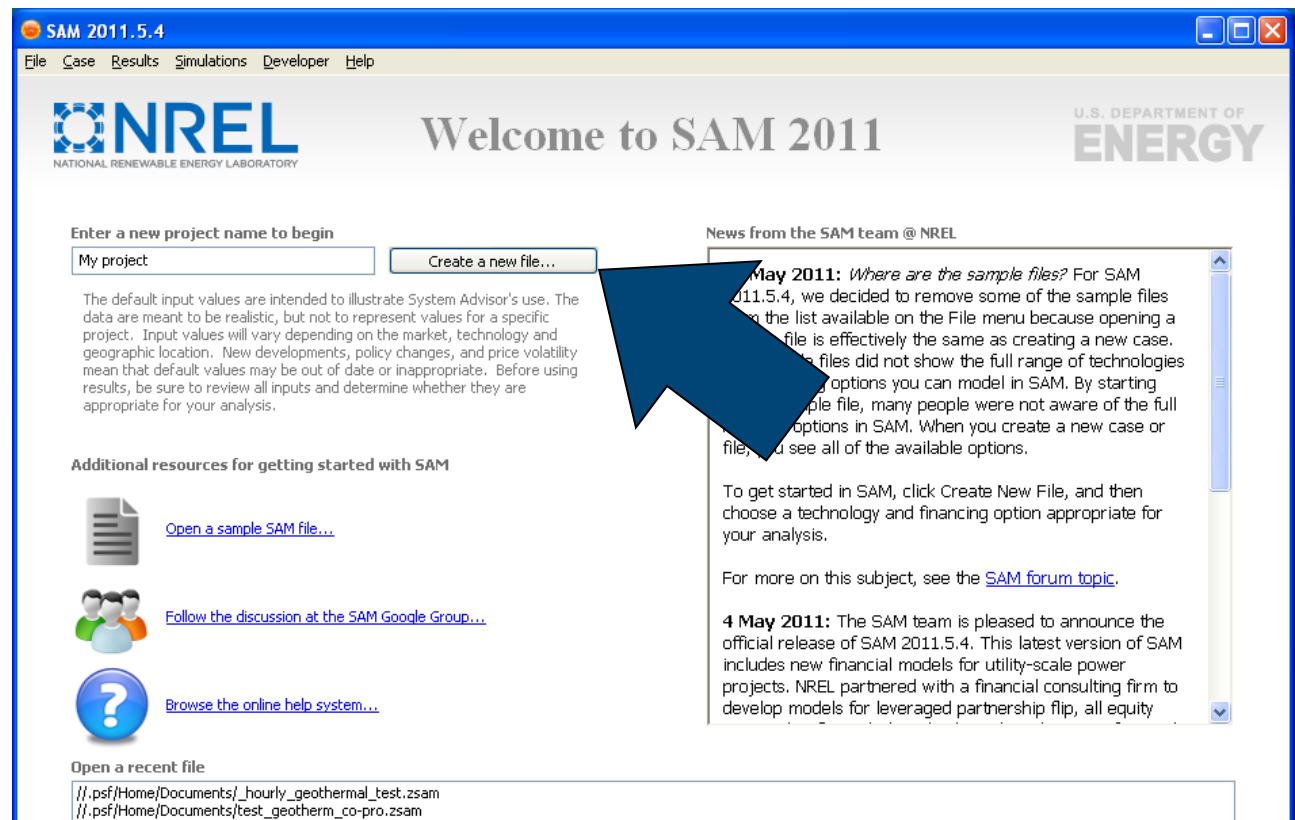
MODELING A GEOTHERMAL FACILITY

Initial Screen



SAM's current startup screen

- Click the “Create a new file...” button to create a case and choose the technology option and financing option



Choosing to model geothermal



- 1) Click on “Geothermal”
- 2) Select the “Geothermal Power” sub-category.
 - With the technology sub-category selected, the appropriate financing categories will appear.

- 3) Click on “Utility Market”
- 4) Select IPP



Inputs - General



The case you created becomes a tab.



Select different input pages by clicking an item in this list



Run the model



The screenshot shows the SAM 2011.5.23 software interface. The title bar reads 'SAM 2011.5.23: untitled1'. The menu bar includes 'File', 'Case', 'Results', 'Simulations', 'Developer', and 'Help'. A tab labeled 'My project' is active. Below the tab, a dropdown menu shows 'Select Technology and Market...' and '[Geothermal, Independent Power Producer]'. The left sidebar contains a list of input categories: 'System Summary' (with a sigma icon), 'Financing' (with a money icon), 'Tax Credit Incentives' (with a person icon), 'Payment Incentives' (with a carrot icon), 'Annual Performance' (with a calendar icon), 'Geothermal System Costs' (with a bag icon), 'Resource' (with a red icon), 'Plant and Equipment' (with a green icon), 'Energy Payment Dispatch' (with a green icon), and 'User Variables' (with a brown icon). The main area displays the 'System Summary' page with the following data:

System Summary	
Nameplate Capacity	15000 kW
Total Direct Cost	52,842,526.87 \$
Total Installed Cost	63,146,819.61 \$
Total Installed Cost per Capacity	4,209.79 \$/kW
Analysis Period	30 years
Inflation Rate	2.5 %
Real Discount Rate	5.5 %

At the bottom of the interface is a toolbar with icons for running the model (green arrow), saving (disk), undo (curved arrow), redo (curved arrow), and a calendar icon.

Input pages specific to geothermal; other pages are similar across technologies





Resource information

- temperature, depth, flow rate, and type (hydrothermal or EGS)

Costs

- Drilling, exploration, production, and injection
- Plant, piping and related equipment
- Pumps and casing
- O&M

Financial assumptions

- Loan parameters for all projects
- Target IRR for utility projects
- Incentives and tax credits

Reservoir parameters to calculate pressure change across the reservoir

Inputs – Geothermal Resource



SAM can lookup geothermal resource data for many places in the continental US

SAM 2011.5.23: untitled1

File Case Results Simulations Developer Help

My project x

Select Technology and Market... [Geothermal, Independent Power Producer]

System Summary Σ

Financing

Analysis: 30 years

Tax Credit Incentives

Payment Incentives

Annual Performance

Degradation: 1 % per year
Availability: 100 %

Geothermal System Costs

Total Installed: \$ 63,146,820
Est. per Capacity (\$/kW): \$ 4,210

Resource

Temp: 200 °C
Depth: 2000 m

Plant and Equipment

Plant Capacity: 15 MW
Design Temp: 200 °C

Energy Payment Dispatch

User Variables

Resource Characterization

Resource Type: ☒ Hydrothermal ☐ Enhanced Geothermal System (EGS)

Lookup temp and depth for a location...

Total Resource Potential MW

Resource Temperature °C

Resource Depth m

Reservoir Parameters

☐ Enter change in pressure across the reservoir in units of psi-h per 1000 lb:

☐ Calculate the reservoir pressure change using simple fracture flow (EGS only)

☒ Calculate the reservoir pressure change using permeability * area

Width m

Height m

Permeability Darcy units

Distance From Injection to Production Wells m

Fracture aperture m

Number of fractures

Fracture width m

Fracture angle deg from horizontal

Subsurface water loss % of water injected

Calculated Design

Pressure change across reservoir psi bar

Average reservoir temperature °F °C

Production well bottom hole pressure psi bar

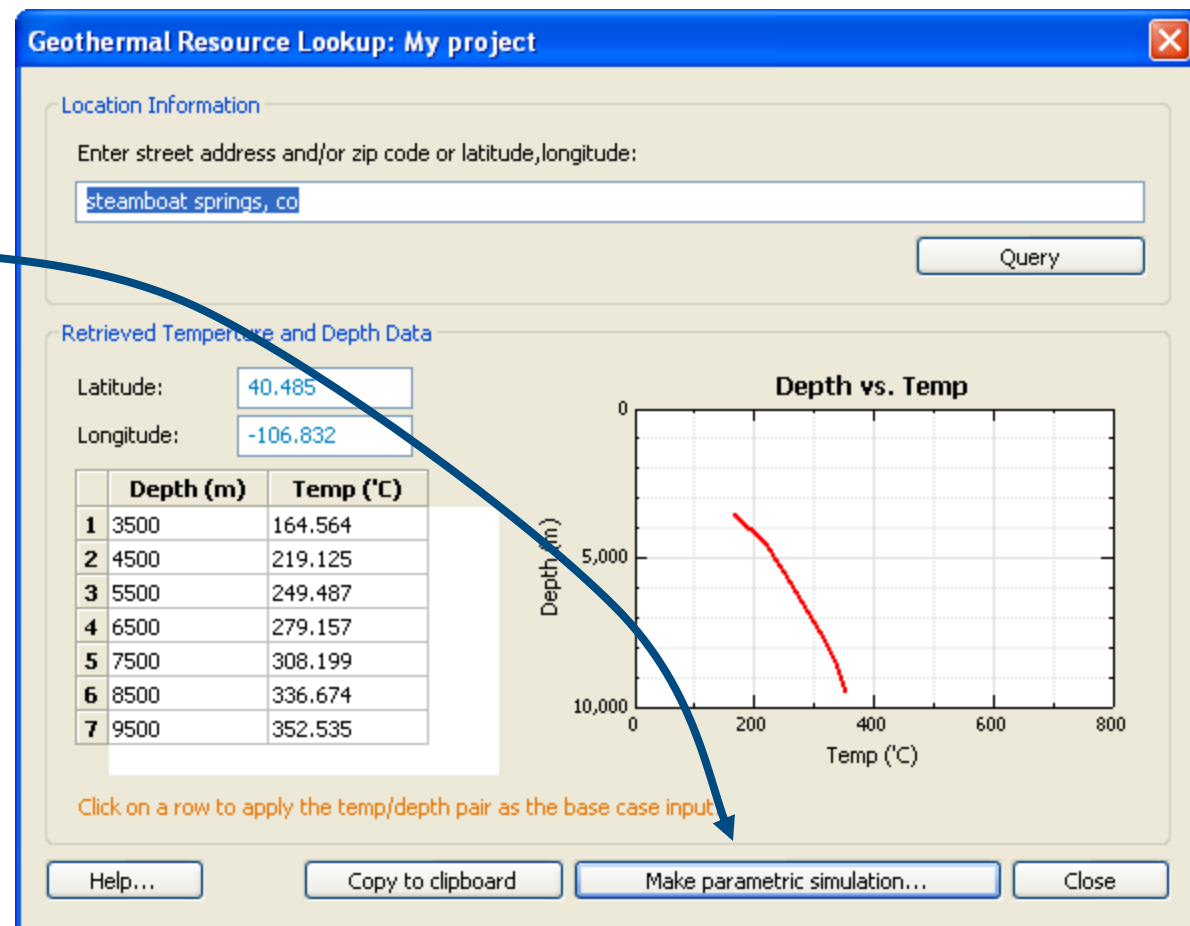
Messages:

Inputs – Geothermal Resource



Clicking the “Lookup temp and depth for a location...” button will bring up the Geothermal Resource Lookup dialog box

If SAM finds data for the location, it will display a temperature vs. depth graph. Then you can have SAM automatically enter multiple values for temperature and depth and do a run for each input (called a “parametric” simulation).

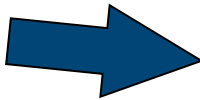


Inputs – Plant and Equipment



Here you can choose:

- How to specify the size of the project:
(plant size vs. # of wells)
- What type of plant to model (Binary vs. Flash)
- How to calculate the temperature decline
- Resource flow rate



SAM 2011.5.23: untitled1

File Case Results Simulations Developer Help

My project x

Select Technology and Market... [Geothermal, Independent Power Producer]

System Summary Σ

Financing

Analysis: 30 years

Tax Credit Incentives

Payment Incentives

Annual Performance

Degradation: 1 % per year
Availability: 100 %

Geothermal System Costs

Total Installed: \$ 85,376,283
Est. per Capacity (\$/kW): \$ 5,732

Resource

Temp: 219 °C
Depth: 4500 m

Plant and Equipment

Plant Capacity: 15 MW
Design Temp: 219 °C

Energy Payment Dispatch

User Variables

Plant Configuration

☒ Specify plant output: 15000 kW
☐ Use exact number of wells: 3 wells

Number of Wells in Analysis: 2.41097 wells

Actual Plant Efficiency: 12.6329 w-hr/lb

Gross Plant Output: 16.9211 MW

Net Plant Output: 15 MW

Conversion Plant Type

☒ Binary Plant Efficiency: 95 %
☐ Flash Subtype: Unconstrained Single Flash

☒ Automatically set to resource temp

Enter Plant Design Temperature (EGS only): 200 °C Plant Design Temperature: 219 °C

Temperature Decline

☒ Specify temp decline rate: 0.3 %/yr
☐ Calculate temp decline rate (EGS only)

Max. temp decline before reservoir replacement: 30 °C

Flash Technology

Wet Bulb Temperature: 15 °C
Ambient Pressure: 14.7 psi

Pumping Parameters

Production Well Flow Rate: 70 kg/s per well
Pump Efficiency: 60 %
Pressure Difference Across Surface Equipment: 25 psi
Excess Pressure at Pump Suction: 50.76 psi
Production Well Diameter: 10 inches
Production Pump Casing Size: 9.625 inches
Injection Well Diameter: 10 inches

Pump Depth: 2270.5 ft
Pump Work: 1.92109 MW
Pump Size: 1068.54 hp

Messages:

Inputs – System Costs



Three categories of costs:

Cost to build

- Direct & indirect capital
- Drilling & stimulation
- Surface equipment
- Pumps and casing



Operating costs

Recapitalization costs

SAM 2011.5.23: untitled1

File Case Results Simulations Developer Help

My project

Select Technology and Market... [Geothermal, Independent Power Producer]

System Summary

Financing
Analysis: 30 years

Tax Credit Incentives

Payment Incentives

Annual Performance
Degradation: 1 % per year
Availability: 100 %

Geothermal System Costs
Total Installed: \$ 85,976,283
Est. per Capacity (\$/kW): \$ 5,732

Resource
Temp: 219 °C
Depth: 4500 m

Plant and Equipment
Plant Capacity: 15 MW
Design Temp: 219 °C

Energy Payment Dispatch

User Variables

Number of Wells to Drill
The number of production wells required is determined on the Geothermal Plant page. Here you can decide if any of the confirmation wells can be used for production wells, and how many injection wells will be used in the analysis.

Total Production Wells Required: 2.41097
% of Confirmation Wells Used for Production: 50 %
Number of Confirmation Wells: 1
Number of Production Wells to be Drilled: 1.41097
Ratio of Injection Wells to Production Wells: 0.5
Number of Injection Wells to be Drilled: 1.20548

Drilling and associated costs

	Cost multiplier (based on the cost of a production well)	Cost per well	# of wells	Drilling cost	Non-drilling cost	Total	
Exploration	0.5	\$ 2,616,738.76	2	\$ 5,233,477.52	\$ 750,000.00	\$ 5,983,477.52	
Confirmation	1.2	\$ 6,280,173.02	2	\$ 12,560,346.04	\$ 250,000.00	\$ 12,810,346.04	
Cost curve							
Production	Med	\$ 5,233,477.52	1.41097	\$ 7,384,270.51			
Injection	Med	\$ 5,233,477.52	1.20548	\$ 6,308,874.01			
Production and Injection Wells to be Drilled				2.61645	\$ 13,693,144.52	\$ 250,000.00	\$ 13,943,144.52
Surface Equipment, Installation		\$ 125,000.00	3.61645		\$ 452,056.54	\$ 452,056.54	
Stimulation Cost		\$ 1,000,000.00	3.61645		\$ 3,616,452.34	\$ 3,616,452.34	

Plant Capital Cost
Plant Capacity: 16921.1 kW Cost: \$ 1,800.00 \$/kW Power Plant Cost: \$ 30,457,965.71

Pump cost inputs
Installation and Casing Cost: \$ 50.00 \$/ft Pump Depth: 2270.5 ft \$ 113,524.91
Pump Cost: \$ 12,479.20 \$/hp Pump Size: 1068.54 hp \$ 407,327.53 [= \$/hp x sqrt(hp)]
of Pumps Required: 2.41097 Cost of Pump: \$ 521,452.45 Total Pump Cost: \$ 1,257,205.28

Recapitalization Cost
Specified Recapitalization Cost: \$ 23,000,000.00
Calculate: \$ 23,000,000.00
Note: Calculated recapitalization cost includes drilling costs, pump costs, and surface equipment. When the reservoir temperature drops below an allowable minimum, new wells must be drilled and costs accounted for in the out years of the analysis.

Direct Capital Costs
Total Capital Cost: \$ 68,520,647.95
Contingency: 5 % \$ 3,426,032.40
Total Direct Cost: \$ 71,946,680.34
Total Installed Cost: \$ 85,976,283.01
Total Installed Cost per Capacity (\$/kW): \$ 5,731.75

Indirect Capital Costs

	% of Direct Cost	Non-fixed Cost	Fixed Cost	Total
Engineer, Procure, Construct	16 %	\$ 11,511,468.86	\$ 0.00	\$ 11,511,468.86
Project, Land, Miscellaneous	3.5 %	\$ 2,518,133.81	\$ 0.00	\$ 2,518,133.81
Sales Tax of	0 %	applies to 80 % of Direct Cost		\$ 0.00
Total Indirect Cost				\$ 14,029,602.67

Operation and Maintenance Costs

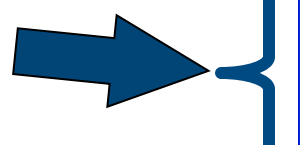
	First Year Cost	Escalation Rate (above inflation)
Fixed Annual Cost	0.00 \$/yr	0 %
Fixed Cost by Capacity	50.00 \$/kW-yr	0 %
Variable Cost by Generation	0.00 \$/MWh	0 %
Fossil Fuel Cost	0.00 \$/MMBTU	0 %

Notes
1) Escalation rates do not apply to O&M annual schedules, only first year values.
2) Fossil fuel cost is not applicable to PV or Dish Stirling systems. Set to zero for these systems.

Inputs – Financial Assumptions



Financial inputs are entered on three pages: Financing, Tax Credit Incentives, and Payment Incentives




SAM 2011.5.23: untitled1

File Case Results Simulations Developer Help


My project x


Select Technology and Market... [Geothermal, Independent Power Producer]


System Summary Σ

Financing 


Analysis: 30 years

Tax Credit Incentives 


Payment Incentives 

Annual Performance 


Degradation: 1 % per year
Availability: 100 %

Geothermal System Costs 


Total Installed: \$ 85,976,283
Est. per Capacity (\$/kW): \$ 5,732


Resource 

Temp: 219 °C
Depth: 4500 m

Plant and Equipment 

Plant Capacity: 15 MW
Design Temp: 219 °C

Energy Payment Dispatch 

User Variables 

General

Analysis Period: 30 years
Inflation Rate: 2.50 %
Real Discount Rate: 5.50 %
Nominal Discount Rate: 8.14 %

Taxes and Insurance

Federal Tax: 30.00 %/year
State Tax: 7.00 %/year
Sales Tax: 0.00 %
Insurance: 1.00 % of install

Salvage Value

Net Salvage Value: 0.00 % of installed cost
End of Analysis Period Value: \$ 0.00

Property Tax

Assessed Percent: 100.00 % of install
Assessed Value: \$ 85,976,283.01
Assessed Value Decline: 0.00 %/year
Property Tax: 1.00 %/year

Construction Period

Loan	Percent of Installed Costs	Up-front Fee (%)	Months Prior to Operation	Interest Rate (Annual)	Principal Amount	Interest	Total Cost
Loan 1	0	0	0	0	\$ 0.00	\$ 0.00	
Loan 2	0	0	0	0	\$ 0.00	\$ 0.00	
Loan 3	0	0	0	0	\$ 0.00	\$ 0.00	
Loan 4	0	0	0	0	\$ 0.00	\$ 0.00	
Loan 5	0	0	0	0	\$ 0.00	\$ 0.00	
Totals:	0				\$ 0.00	\$ 0.00	

Note: If you specify construction period loans, the sum of percentages in the Percent of Installed Costs column must equal 100.

Loan Parameters

Installed Cost: \$ 85,976,283.01
Construction Financing Cost: \$ 0.00
Principal Amount: \$ 34,390,513.20
Loan Term: 20 years
Loan Rate: 8 %/year
Debt Fraction: 40 %
WACC: 11.08 %

Solution Mode

Co-Production vs. Geothermal Power



Resource

- Co-Production model assumes a steady state for the temperature of the resource, essentially expecting that the heat recovered from the co-produced water has no impact on the resource temperature
- Geothermal Power model expects temperature declines over time and tries to account for costs necessary to replace the resource

Parasitic Power

- Co-Production model simply calculates a possible electrical generation capacity based on thermodynamics or performance curves for existing generation units
- Geothermal Power model attempts to account for pumping energy and associated costs

Choosing to model co-production



- 1) Click on “Geothermal”
- 2) Select the “Geothermal Co-Production” sub-category.
- 3) Click on “Commercial Market”

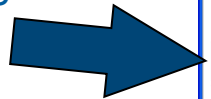


Inputs – General Co-Production



SAM has two input pages specific to the Co-Production model: Resource and Power Generation, and Co-Production Costs

All of the non-cost inputs are entered on the “Resource and Power Generation” input page



SAM 2011.5.23: untitled1

File Case Results Simulations Developer Help

My project x

Select Technology and Market... [Geothermal Co-Production, Commercial]

System Summary

Utility Rate

Financing

Analysis: 30 years

Tax Credit Incentives

Payment Incentives

Annual Performance

Degradation: 1 % per year

Availability: 90 %

Resource and Power Generation

Co-Production Costs

Electric Load

Annual Energy: 0 kWh

Annual Peak: 0 kW

User Variables

Specify Resource

Resource temperature 260 °F 126.7 °C

Resource Flow Rate 1000 bbl/day 29.2 gal/min 1.8 kg/s

Choose how to model geothermal production

☒ Model power output theoretically

☐ Model power output based on existing systems

Theoretical Model Utilization Efficiency - User Defined

Resource power potential 37.8 kW

Enter efficiency curve...

Calculated efficiency @ resource temp 25.75 %

☒ Size plant based on resource power potential

☐ Specify plant design net output

Plant design output 250 kW

Plant outlet temperature 170 °F

Ambient Temperature 50 °F

Existing System PureCycle

Resource power potential 3.1 kW

☒ Size plant based on resource power potential

☐ Specify the number of units

System is sized to match resource but uses thermal efficiency curve based on performance of existing system

Plant design output 260.0 kW/unit

Number of units 1

Cooling Water Temperature 50 °F

Plant design net output 37.8 kW

Actual expected plant output 37.8 kW

Graph

Resource temperature vs. utilization efficiency - user defined

Efficiency (%)

Temperature (°C)

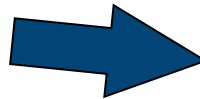
Legend:

- Extrapolated values
- Interpolated values
- User defined values
- Resource temperature

Inputs – Costs for Co-Production



SAM's Co-Production Cost input page contains inputs for capital and O&M costs



SAM 2011.5.23: untitled1

File Case Results Simulations Developer Help

My project x

Select Technology and Market... [Geothermal Co-Production, Commercial]

System Summary Σ

Utility Rate

Financing

Analysis: 30 years

Tax Credit Incentives

Payment Incentives

Annual Performance

Degradation: 1 % per year
Availability: 90 %

Resource and Power Generation

Co-Production Costs

Electric Load

Annual Energy: 0 kWh
Annual Peak: 0 kW

User Variables

Direct capital costs

Plant design net power output: 37.8 kW

Installed plant cost per net power output (typical): \$ 5,250.00 \$/kW

Installed plant cost: \$ 198,332.93

Other Costs

Extra installation costs (remote or difficult to reach location, etc.): \$ 0.00

Extra piping, storage tank, other infrastructure costs: \$ 0.00

Transmission line costs: \$ 0.00

Plant permitting costs: \$ 0.00

Transmission agreements and PPA costs: \$ 0.00

Other Legal Costs: \$ 0.00

Total other costs: \$ 0.00

Total installed costs

Total installed cost: \$ 198,332.93

Estimated total installed plant cost per net power output (\$/kW): \$ 5,250.00

Operation and Maintenance Costs

	First Year Cost	Escalation Rate (above inflation)
Fixed Annual Cost	Value: 20,000.00 \$/yr	0 %
Fixed Cost by Capacity	Value: 0.00 \$/kW-yr	0 %
Variable Cost by Generation	Value: 0.00 \$/MWh	0 %
Fossil Fuel Cost	Value: 0.00 \$/MMBTU	0 %

Notes

1) Escalation rates do not apply to O&M annual schedules, only first year values.

2) Fossil fuel cost is not applicable to PV or Dish Stirling systems. Set to zero for these systems.



SAM Geothermal Analysis

RUNNING SAM, OUTPUTS

Running the model



Click the green arrow on the bottom left to run the model

SAM 2011.5.23: untitled1

File Case Results Simulations Developer Help

My project x

Select Technology and Market... [Geothermal, Independent Power Producer]

System Summary Σ

Financing

Analysis: 30 years

Tax Credit Incentives

Payment Incentives

Geothermal System Costs

Total Installed: \$ 135,079,845
Est. per Capacity (\$/kW): \$ 9,005

Resource

Temp: 200 °C
Depth: 6000 m

Plant and Equipment

Plant Capacity: 15 MW
Design Temp: 200 °C

Energy Payment Dispatch

User Variables

Resource Characterization

Resource Type: ☒ Hydrothermal ☐ Enhanced Geothermal System (EGS)

Total Resource Potential: 210 MW

Resource Temperature: 200 °C

Resource Depth: 6000 m

Lookup temp and depth for a location...

Reservoir Parameters

☐ Enter change in pressure across the reservoir in units of psi-h per 1000 lb: 0.35

☐ Calculate the reservoir pressure change using simple fracture flow (EGS only)

☒ Calculate the reservoir pressure change using permeability * area

Width: 500 m

Height: 100 m

Permeability: 0.05 Darcy units

Distance From Injection to Production Wells: 1500 m

Fracture aperture: 0.0004 m

Number of fractures: 6

Fracture width: 175 m

Fracture angle: 15 deg from horizontal

Subsurface water loss: 2 % of water injected






Calculated Design

Pressure change across reservoir: 951.764 psi 65.6218 bar

Average reservoir temperature: 392 °F 200 °C

Production well bottom hole pressure: 6942.84 psi 478.692 bar

Messages:

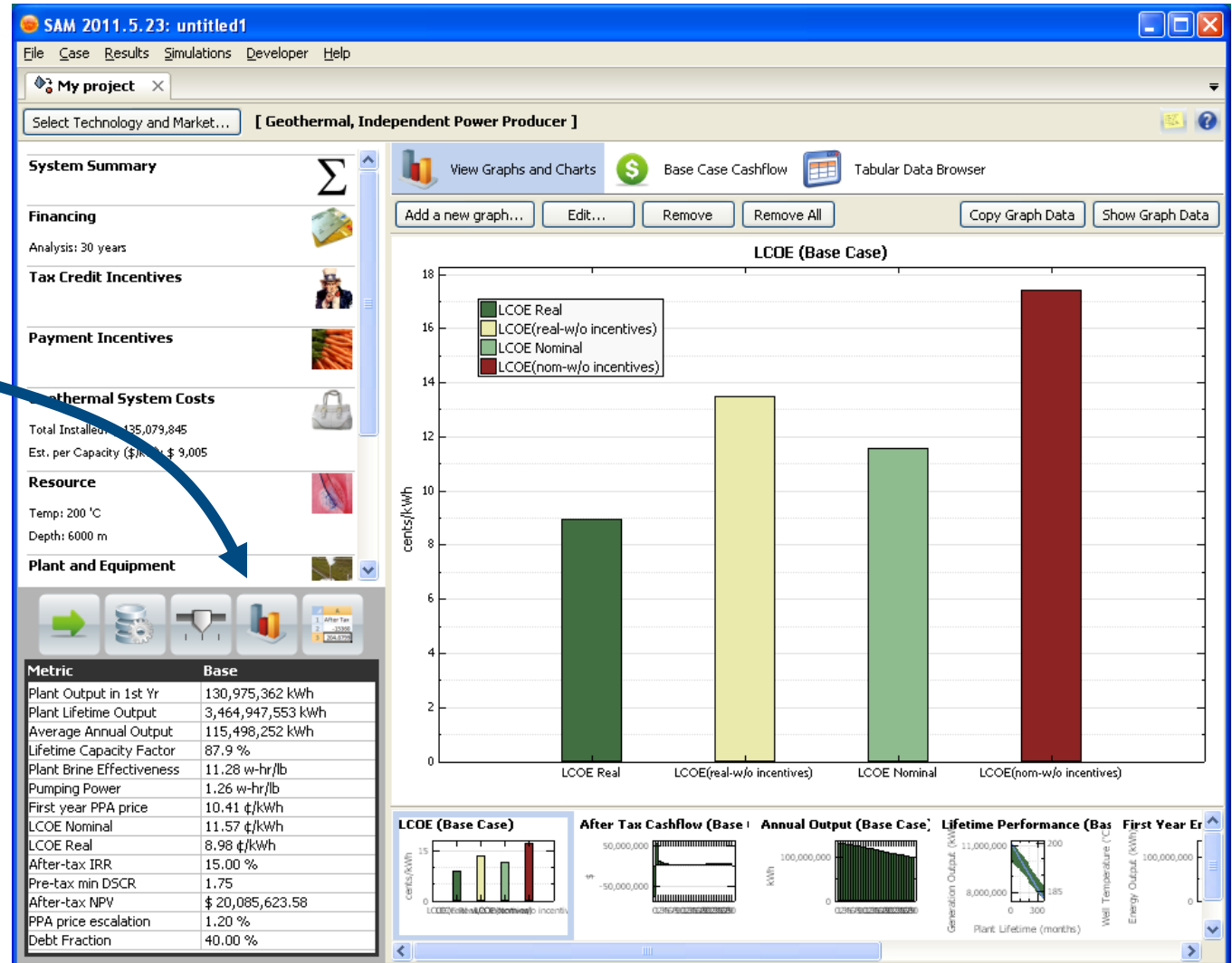
Default Result Page



When SAM completes the model run, it will default to display graphic results

You can always see the most current set of results by clicking on the "Results" button

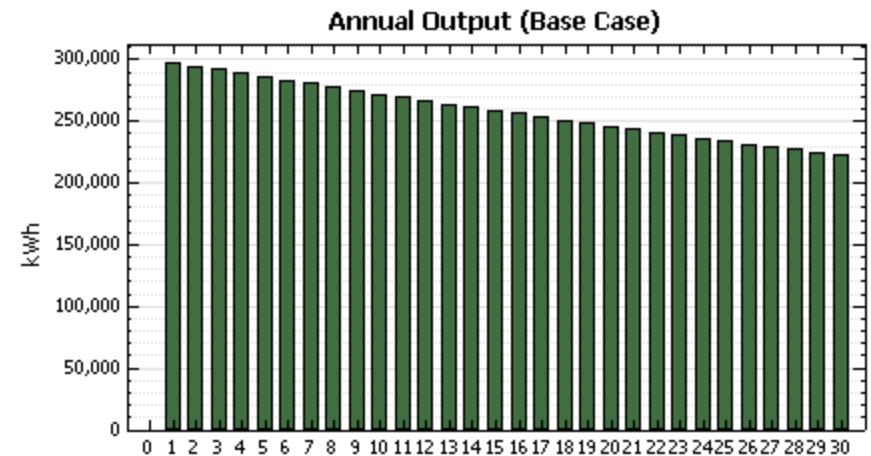
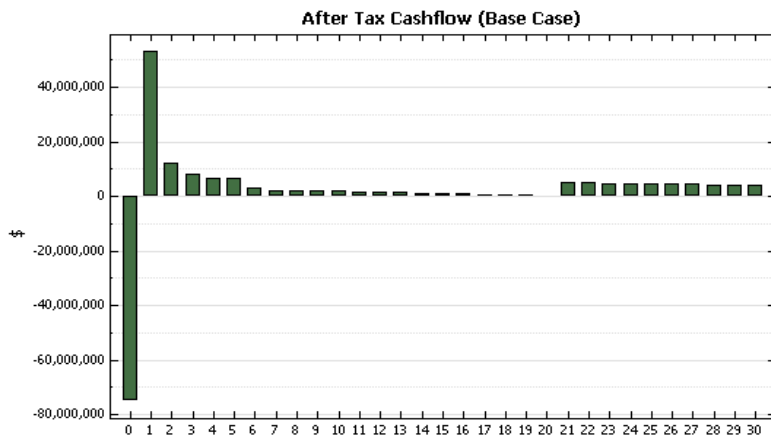
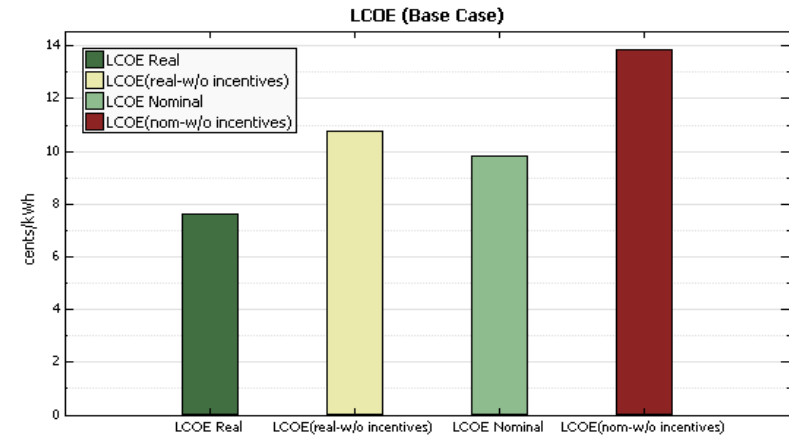
When showing results, SAM displays basic metrics on the bottom left



Results – Default Graphs



SAM creates several graphs by default, showing financial and energy generation results



Results – Tabular Cash Flow



Numeric values can easily be viewed and exported

Select
“Base Case Cashflow”
or
“Tabular Data Browser”
to view numeric data

SAM 2011.6.23: untitled1

File Case Results Simulations Reports Developer Help

My project x

Select Technology and Market... [Geothermal, Independent Power Producer]

System Summary Σ

Financing

Analysis: 30 years

Tax Credit Incentives

Payment Incentives

Annual Performance

Degradation: 0 % per year

Availability: 93 %

Geothermal System Costs

Total Installed: \$ 89,852,879

Est. per Capacity (\$/kW): \$ 5,990

Resource

Temp: 250 °C

View Graphs and Charts

Base Case Cashflow

Tabular Data Browser

Copy to clipboard Save as CSV... Send to Excel

	0	1	2	3	4	5
Energy (kWh)	0	121,806,251	120,938,356	120,057,788	119,165,362	118,272,936
Energy Price (\$/kWh)	0	0.079	0.08	0.081	0.082	0.083
Energy Value (\$)	0	9,597,443.37	9,643,408.3	9,688,071.68	9,731,449.99	9,774,828.3
Operating Expenses						
Recapitalization	0	0	0	0	0	0
Fixed O&M Annual	0	0	0	0	0	0
Fixed O&M	0	750,000	768,750	787,968.75	807,667.97	827,367.19
Variable O&M	0	0	0	0	0	0
Fuel O&M	0	0	0	0	0	0
Insurance	0	898,528.79	920,992.01	944,016.81	967,617.23	991,217.65
Property Assessed Value	0	89,852,878.87	89,852,878.87	89,852,878.87	89,852,878.87	89,852,878.87
Property Taxes	0	898,528.79	898,528.79	898,528.79	898,528.79	898,528.79
Net Salvage Value	0	0	0	0	0	0
Total Operating Expenses	0	2,547,057.58	2,588,270.8	2,630,514.35	2,673,813.99	2,717,102.63
Operating Income	0	7,050,385.8	7,055,137.51	7,057,557.33	7,057,636.01	7,057,714.67
Financing						
Debt Balance	0	-35,941,151.55	-35,155,758	-34,307,532.97	-33,391,449.93	-32,400,366.89
Debt Interest Payment	0	2,875,292.12	2,812,460.64	2,744,602.64	2,671,315.99	2,597,989.34
Debt Repayment	0	785,393.55	848,225.03	916,083.04	989,369.68	1,062,656.32
Debt Total Payment	0	3,660,685.67	3,660,685.67	3,660,685.67	3,660,685.67	3,660,685.67
Federal IBI	0					
State IBI	0					
Utility IBI	0					
Other IBI	0					
Total IBI	0					
Federal CBI	0					
State CBI	0					
Utility CBI	0					

Metric Base

Plant Output in 1st Yr	130,974,463 kWh
Plant Lifetime Output	3,448,861,192 kWh
Average Annual Output	114,962,040 kWh
Lifetime Capacity Factor	87.5 %
Plant Brine Effectiveness	14.75 w-hr/lb
Pumping Power	1.35 w-hr/lb
First year PPA price	7.88 \$/kWh
LCOE Nominal	8.76 \$/kWh
LCOE Real	6.80 \$/kWh
After-tax IRR	15.00 %
Pre-tax min DSCR	1.78
After-tax NPV	\$ 14,149,467.39
PPA price escalation	1.20 %
Debt Fraction	40.00 %

Results – Tabular Data Browser



Numeric values can easily be viewed and exported

SAM 2011.5.23: untitled1

File Case Results Simulations Developer Help

My project x

Select Technology and Market... [Geothermal, Independent Power Producer]

System Summary

Financing

Analysis: 30 years

Tax Credit Incentives

Payment Incentives

Geothermal System Costs

Total Installed: \$ 135,079,845
Est. per Capacity (\$/kW): \$ 9,005

View Graphs and Charts Base Case Cashflow **Tabular Data Browser**

Choose Simulation: Base Case Copy to clipboard Save as CSV...

Output Variables

- Metrics
- Monthly Data
- Data: 30 values
- Annual Data
 - ☒ After Tax Cashflow
 - ☒ Cumulative kWh/kW
 - ☐ Debt Balance
 - ☐ Debt Interest Payment
 - ☐ Debt Repayment
 - ☐ Debt Total Payment
 - ☐ Energy (kWh)
 - ☐ Energy Price (\$/kWh)
 - ☐ Energy Value (\$)
 - ☐ Energy dispatched in period
 - ☐ Energy generated in April
 - ☐ Energy generated in August
 - ☐ Energy generated in December
 - ☐ Energy generated in February
 - ☐ Energy generated in January

	After Tax Cashflow	Cumulative kWh/kW
1	-8.10479e+007	0
2	5.71805e+007	8731.69
3	1.30257e+007	17401.4
4	8.82947e+006	26008.6
5	6.95668e+006	34552.4
6	6.91824e+006	43032.4
7	3.01575e+006	51448
8	2.41369e+006	59798.7
9	2.35885e+006	68083.9
10	2.29792e+006	76303.3
11	2.23056e+006	84456.4
12	2.15638e+006	92542.9
13	2.07498e+006	100562
14	1.98592e+006	108515
15	1.88873e+006	116400
16	1.78289e+006	124217
17	1.66786e+006	131966
18	1.41181e+006	139540
19	1.23935e+006	147018
20	1.0809e+006	154419
21	911349	161745
22	6.23315e+006	168995
23	6.19252e+006	176172
24	6.15045e+006	183275
25	6.10688e+006	190305
26	6.06179e+006	197264
27	6.01512e+006	204150
28	5.96685e+006	210966

Metric Base

Plant Output in 1st Yr	130,975,362 kWh
Plant Lifetime Output	3,464,947,553 kWh
Average Annual Output	115,498,252 kWh
Lifetime Capacity Factor	87.9 %
Plant Brine Effectiveness	11.28 w-hr/lb
Pumping Power	1.26 w-hr/lb
First year PPA price	10.41 ¢/kWh
LCOE Nominal	11.57 ¢/kWh
LCOE Real	8.98 ¢/kWh
After-tax IRR	15.00 %
Pre-tax min DSCR	1.75
After-tax NPV	\$ 20,085,623.58
PPA price escalation	1.20 %
Debt Fraction	40.00 %

Clear all



SAM Geothermal Analysis

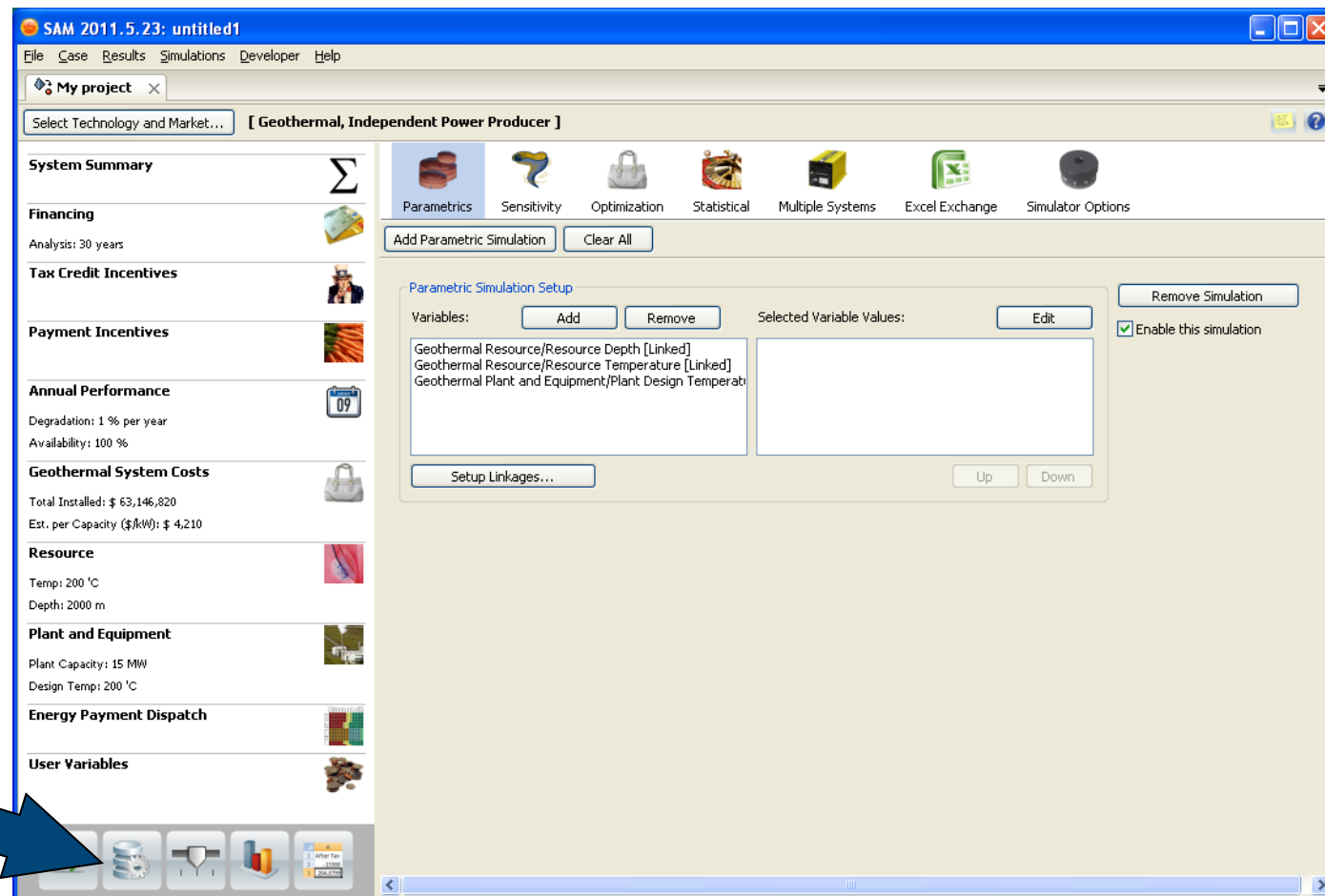
ADVANCED TOPICS

Advanced Topics – Simulations



Most advanced modeling techniques are accessed through the “Simulations” menu, or the “Configure Simulations” button on the bottom left

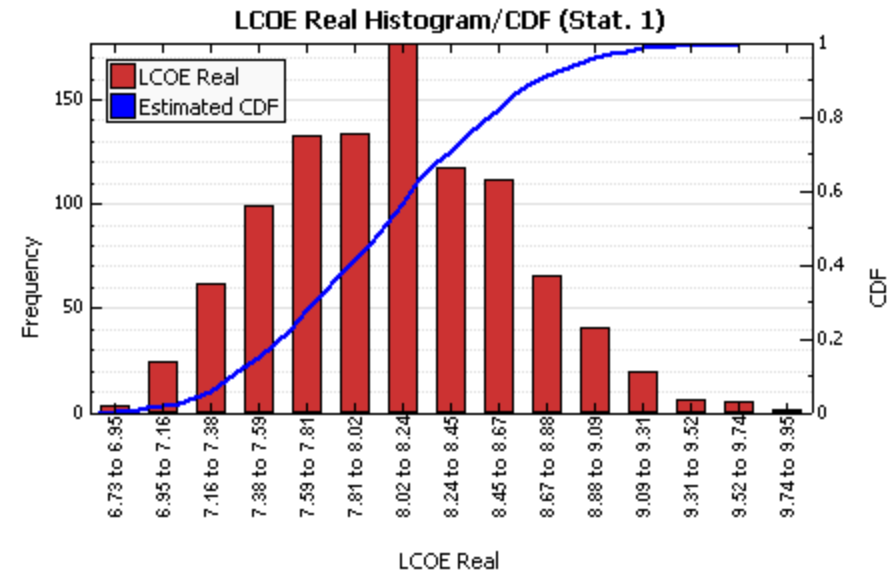
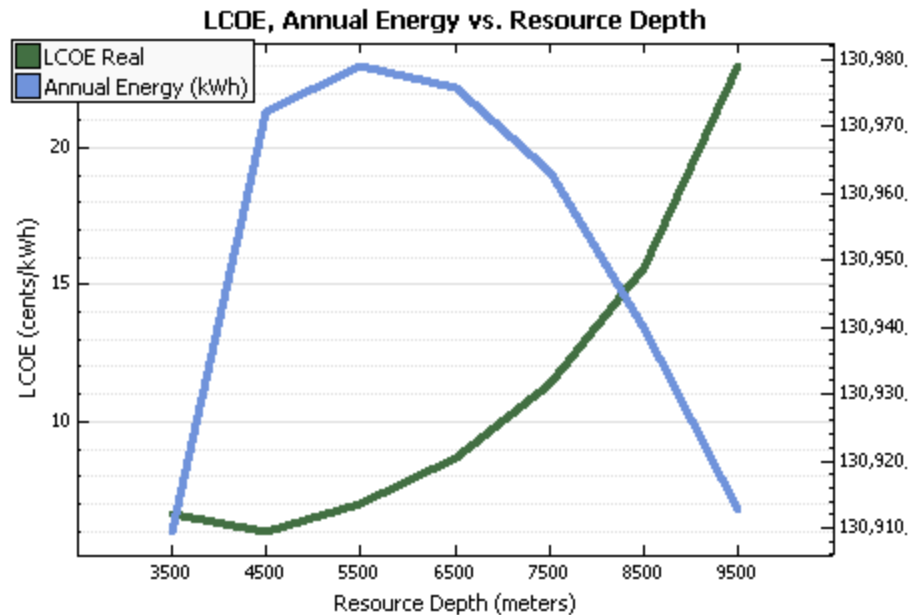
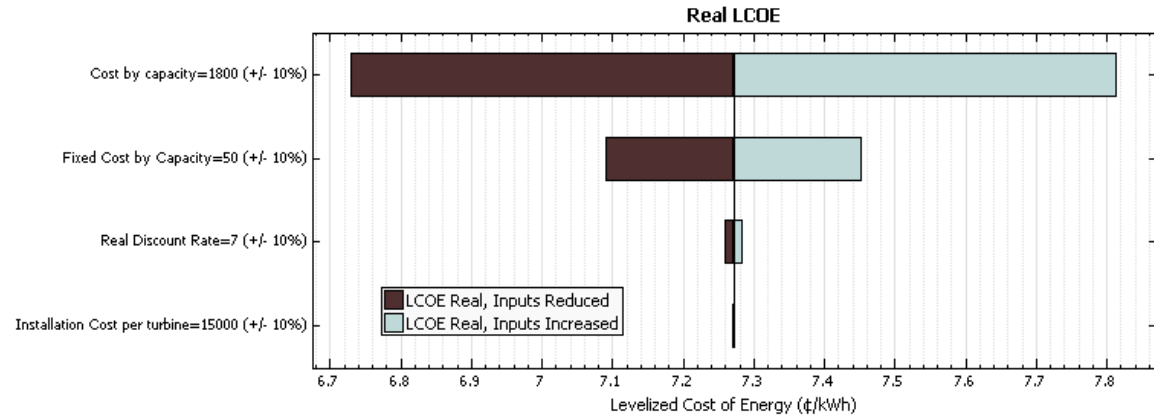
Configure
Simulations
button



Advanced Topics - Uncertainty



Graphic outputs from uncertainty modeling in SAM



Advanced Topics - Other



Excel Exchange (Linking with Excel on Windows)

- Use Excel to calculate input values for SAM to use in analysis
- e.g. costs could be calculated externally in detailed spreadsheet and automatically updated on SAM's cost input page

Scripting – SAMUL

- A language, similar to VBA, that allows a user to control SAM runs
- Easier than using the full API, since no external development environment is necessary

API

- SAM has a full featured Application Programming Interface
- SAM will generate example code in C, VBA, Python, and Matlab to show how to run a SAM analysis

See help and sample files for more information

Thank You!



SAM Geothermal Analysis

DEMO